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Information technology — Automatic identification and data capture techniques — Interleaved 2 of 5 bar code symbology specification

Technologies de l'information — Techniques d'identification automatique et de capture des données — Spécifications des symbologies des codes à barres, code 2 parmi 5 entrelacé

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Contents

Page

Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

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ISO/IEC 16390 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

This second edition cancels and replaces the first edition (ISO/IEC 16390:1999), which has been technically revised.

Introduction

The technology of bar coding is based on the recognition of patterns encoded in bars and spaces of defined dimensions. There are numerous methods of encoding information in bar code form, known as symbologies. Interleaved 2 of 5 is one such symbology. The rules defining the translation of characters into bar and space patterns and other essential features are known as the symbology specification.

In the past, symbology specifications were developed and published by a number of organizations, resulting in certain instances in conflicting requirements for certain symbologies.

Manufacturers of bar code equipment and users of bar code technology require publicly available standard symbology specifications to which they can refer when developing equipment and application standards.

Information technology — Automatic identification and data capture techniques — Interleaved 2 of 5 bar code symbology specification

1 Scope

This International Standard specifies the requirements for the bar code symbology known as Interleaved 2 of 5; it specifies Interleaved 2 of 5 symbology characteristics, data character encodation, dimensions, tolerances, decoding algorithms and parameters to be defined by applications. It specifies the Symbology Identifier prefix strings for Interleaved 2 of 5 symbols.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 646, *Information technology — ISO 7-bit coded character set for information interchange*

ISO/IEC 15416, *Information technology — Automatic identification and data capture techniques — Bar code print quality test specification — Linear symbols*

ISO/IEC 15424, *Information technology — Automatic identification and data capture techniques — Data carrier identifiers (including Symbology Identifiers)*

ISO/IEC 19762-1, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 1: General terms relating to AIDC*

ISO/IEC 19762-2, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 2: Optically readable media (ORM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19762-1 and ISO/IEC 19762-2 apply.

4 Requirements

4.1 Symbology characteristics

The characteristics of Interleaved 2 of 5 are:

a) Encodable character set: numeric 0 to 9 (ASCII characters 48 - 57 inclusive, in accordance with ISO/IEC 646);

b) Code type: continuous;

c) Elements per symbol character: 5, of which 2 wide and 3 narrow, encoded as either five bars or five spaces;

d) Character self-checking: yes;

e) Data string length encodable: variable (even number of digits);

f) Bidirectionally decodable: yes;

g) Symbol check character: one, optional (see annex A);

h) Symbol character density: 14 to 18 modules per symbol character pair, depending on wide/narrow ratio;

i) Non-data overhead: 8 to 9 modules, depending on wide/narrow ratio.

4.2 Symbol structure

Interleaved 2 of 5 symbols shall comprise:

a) leading quiet zone;

b) start pattern;

c) one or more pairs of symbol characters representing data (inclusive of optional symbol check character);

d) stop pattern;

e) trailing quiet zone.

4.3 Character encodation

4.3.1 Symbol character structure

Data is encoded as interleaved pairs of symbol characters, the first of which comprises two wide and three narrow bars and the second of which comprises two wide and three narrow spaces, the first bar of the first character being followed by the first space of the second character, then the second bar of the first character and the second space of the second character, and so on until the last space of the second character, which is directly followed by the first bar of the next symbol character pair (or stop pattern).

4.3.2 Data character encodation

Table 1 defines the Interleaved 2 of 5 character encodation. In the columns headed "Binary representation" the character 1 is used to represent a wide element and 0 a narrow element.

Table 1 — Binary representation of character encodation

Data character	Binary representation				
0	0	0	1	1	0
1	1	0	0	0	1
2	0	1	0	0	1
3	1	1	0	0	0
4	0	0	1	0	1
5	1	0	1	0	0
6	0	1	1	0	0
7	0	0	0	1	1
8	1	0	0	1	0
9	0	1	0	1	0

Table 1 uses a modified binary coded decimal encoding scheme. The four left-most bit positions for each character are assigned weights of 1, 2, 4 and 7, from left to right; the fifth position is used for an even parity bit. The sum of the positional weights of the '1' bits is equivalent to the data character value, except in the case of the data character 0, where the weights 4 and 7 are applied. The parity bit ensures that there are always two '1' bits per character.

The following algorithm defines the rules to convert numeric data into the symbol characters of an Interleaved 2 of 5 symbol:

Step in Algorithm	Example
1) Calculate check character if required by the application standard. See 4.7; 2) If the data string, including check characters, has an odd number of digits, add a leading zero; which becomes	367 0367
3) Subdivide the numeric string into digit pairs; which becomes	0367 03 and 67
4) Encode each digit pair in turn as follows: a) Encode the leading digit of the pair into a pattern of bars as shown in Table 1; b) Encode the second digit of the pair into a pattern of spaces as shown in Table 1;	 0 (binary pattern 00110) 3 (binary pattern 11000)
5) Form each symbol character pair by taking the bar and space elements alternately from the patterns derived from steps 4 a) and 4 b), commencing with the first bar of the pattern for the first digit, followed by the first space of the pattern for the second digit.	Binary pattern 0101101000

Figure 1 illustrates the sequence of bar and space elements corresponding to the data character pairs "03 67".

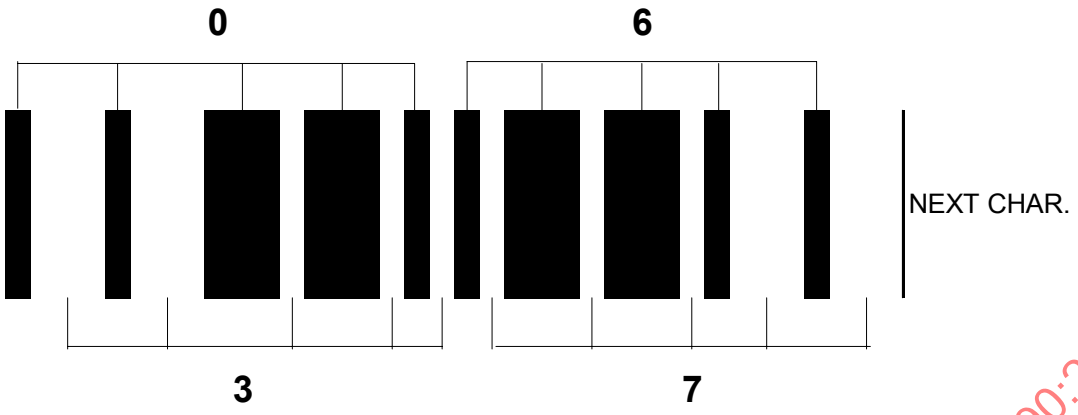

Figure 1 — Interleaved 2 of 5 character pairs, encoding "03 67"

4.3.3 Start and stop patterns

The start pattern shall consist of four narrow elements in the sequence bar - space - bar - space. The stop pattern shall consist of a wide bar - narrow space - narrow bar sequence.

The start pattern shall be positioned at the normal left end of the data symbol characters adjacent to the first bar of the most significant digit. The stop pattern shall be positioned at the normal right end of the data symbol characters adjacent to the final space of the least significant digit.

There is no assigned human readable interpretation of the start and stop patterns and they shall not be transmitted by the decoder.

Figure 2 illustrates the start and stop patterns and their relationship to the symbol data characters.

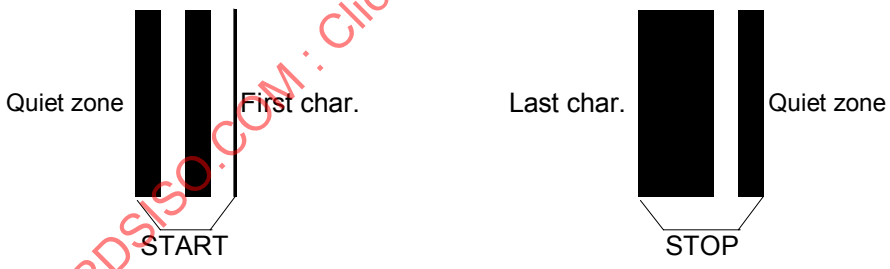

Figure 2 — Start and stop patterns

Figure 3 illustrates a complete Interleaved 2 of 5 bar code symbol for the data "1234" showing the necessary quiet zones.

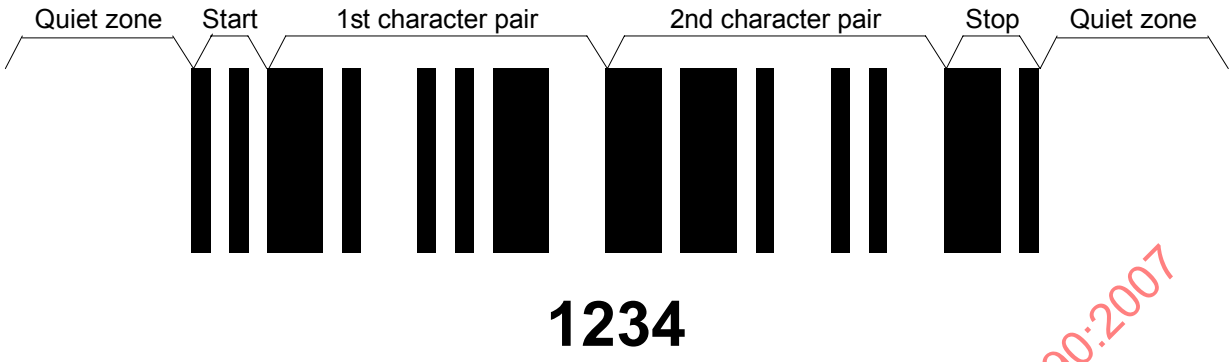

Figure 3 — Interleaved 2 of 5 symbol inclusive of quiet zones

4.3.4 Optional symbol check character

Annex A defines the check character position and calculation.

4.4 Dimensions

Interleaved 2 of 5 symbols shall use the following nominal dimensions:

— width of narrow element (*X*): the *X* dimension of Interleaved 2 of 5 symbols should be defined by the application specification in accordance with the needs of the application in question. See 4.7.1;

— wide/narrow ratio (*N*): 2,0:1 to 3,0:1;

— minimum width of quiet zone: 10*X*;

— recommended minimum bar code height for manual scanning: 5,0 mm or 15 % of symbol width excluding quiet zones, whichever is greater.

The width, *W* (in millimetres) of an Interleaved 2 of 5 symbol, including quiet zones, can be calculated from the following expression:

$$W = [P(4N + 6) + N + 6]X + 2Q$$

where:

W is the symbol width;

P is the number of symbol character pairs;

N is the wide/narrow ratio;

X is the width of a narrow element in millimetres;

Q is the width of the quiet zone in millimetres.

4.5 Reference decode algorithm

Bar code reading systems are designed to read imperfect symbols to the extent that practical algorithms permit. This section describes the reference decode algorithm used in the computation of the decodability value described in ISO/IEC 15416.

1) Confirm presence of a leading quiet zone.

2) Confirm presence of a valid start pattern by checking that the widths of the initial four elements are each less than 7/64 the sum of the next ten elements (if this fails, reverse decoding may be attempted).

3) Decode the exact number of character pairs specified by the application as follows:

   (1) Record the widths of the ten elements of a character pair and accumulate their sum, *S*;

   (2) Compute a threshold, $T = (7 / 64)S$;

   (3) Compare the individual widths with the threshold: if element width is greater than *T*, assume element is wide; if not, assume it is narrow.

4) Verify that in each group of five bars and five spaces two bar and two space elements are wide and three bar and three space are narrow.

5) Using Table 1, convert the wide and narrow pattern of the five bars and five spaces respectively into the first and second digits of the digit pair.

6) After decoding the proper number of character pairs, confirm the presence of a valid stop pattern by checking that the next element width is greater than or equal to the *T* of the previous symbol character and that the widths of the following two elements widths are less than *T*.

7) Confirm the presence of a trailing quiet zone.

4.6 Symbol quality

4.6.1 Test specification

In order to verify whether a symbol meets the specifications in this International Standard it shall be tested using the test specification defined in ISO/IEC 15416, which defines a standardized methodology for measuring and grading bar code symbols, as supplemented in 4.6.2. ISO/IEC 15416 lays down conditions under which measurements should be made; and defines methods of determining an overall quality grade based on the attributes of the bar code symbol. The reference decode algorithm defined in subclause 4.5 of this specification shall be used for the assessment of the "decode" and "decodability" parameters under ISO/IEC 15416.

The overall symbol grade shall be expressed in the form shown in the following example:

1,5 / 10 / 660

where 1,5 is the overall symbol quality grade,

10 is the measuring aperture reference number (in this example 0,25 mm diameter),

660 is the peak response wavelength in nanometers.

ISO/IEC 15416 allows for additional pass/fail criteria to be stipulated by a symbology specification. For Code 39, the additional criteria are given in 4.6.2. Any individual scan profile which does not meet these requirements shall receive a grade of 0.

NOTE Certain application specifications may define a decode algorithm and a method of calculating the decodability value which differ from those specified in 4.5 or ISO/IEC 15416 in their application of the methodology of ISO/IEC 15416.

4.6.2 Additional parameters

4.6.2.1 Wide/narrow ratio

Symbols shall be produced with a nominal *N* from 2,0 to 3,0 inclusive. The measured value of *N* in any scan profile shall be in the range 1,8 to 3,4 inclusive. The wide/narrow ratio in the scan reflectance profile under ISO/IEC 15416 shall be measured and graded as follows:

$1{,}8 \leqslant N \leqslant 3{,}4$ Grade 4

$N < 1{,}8$ or $N > 3{,}4$: Grade 0

4.6.2.2 Quiet zone

The quiet zone at each end of the symbol shall be a minimum of 10*Z*. Both left and right quiet zones on each scan reflectance profile under ISO/IEC 15416 shall be measured and graded as follows:

Quiet Zone $\geqslant$ 10*Z*: Grade 4

Quiet Zone < 10*Z*: Grade 0

NOTE In the preceding subclauses 4.6.2.1 and 4.6.2.2, the requirements are based on the actual, rather than intended, measurements of the parameter; for this reason the *Z* dimension is appropriate rather than the *X* dimension.

4.7 Application-defined parameters

4.7.1 Symbology and dimensional characteristics

In order for an Interleaved 2 of 5 symbol to be printed and to be scannable in a given application it is necessary for the following symbology and dimensional parameters to be specified by the application specification:

1) The number of data characters in the symbol, which may be fixed, variable or variable up to a defined maximum (see A.1);

2) Whether the weighted modulo 10 complement symbol check character is to be used (see A.2) and whether it is to be transmitted by the decoder;

3) Whether a data check character is to be used and if so the algorithm for its calculation;

4) Range of *X* dimension;

5) Range of nominal wide/narrow ratio;

6) Minimum bar height.

NOTE 1 For applications wishing to take advantage of enhanced data security, a symbol check character should be used. See Annex A.2.

NOTE 2 The wide/narrow ratio should be as high as possible within the range specified in 4.4 to maximize reading performance.

An example is given in annex D.

4.7.2 Optical specifications

In order for a bar code symbol to be scannable in a given application, it is necessary to specify certain optical parameters. The selection of the parameters shall be made in the application standard and shall include the specification of:

a) peak response wavelength;

b) spectral half power band width with which the symbol and the scanner shall conform;

c) the spot size of the scanner;

d) the parameters for reflectance of the bars and spaces;

e) the conditions under which optical measurements shall be made;

f) the extent of permissible imperfections within the bar code symbol.

An example is provided in annex D.

4.7.3 Quality specifications

Application specifications should define the minimum overall symbol grade for acceptability (including minimum grade level, required measurement aperture and peak response wavelength) when symbols are measured in accordance with ISO/IEC 15416.

Optionally, an alternative decode algorithm defined in the application specification may be substituted for the reference decode algorithm for the purposes of evaluating the decodability of the symbol.

Annex A
(informative)

Additional features

A.1 Protection against short scans

In Interleaved 2 of 5 symbols, the bar patterns of the start and stop patterns may be found as the respective end and beginning of certain encoded symbol characters within the code. There is therefore no guarantee that a partial scan of the symbol will not produce a valid read for an embedded symbol having fewer characters. There are two additional measures which should be taken to minimize the risk of such partial read.

A.1.1 Fixed length symbols

In any application standard the number of characters encoded in an Interleaved 2 of 5 symbol should be fixed for that application and reading or data processing equipment should be programmed only to accept messages of that defined length.

A.1.2 Bearer bars

Where fixed length symbols cannot be used in an application, bearer bars should be used. The purpose of bearer bars is to reduce the probability of a valid but erroneous short read of the symbol where a scanning beam enters and/or leaves the symbol at the top or bottom. Bearer bars should be added unless technical constraints prevent it or unless the reading or data processing equipment is programmed for fixed length symbols.

Bearer bars should be placed perpendicular to the bars in the symbol, abutting the top and the bottom of the symbol bars over the full length of the symbol. They may extend over the quiet zones and their ends may be joined by vertical bars, provided that quiet zones of no less than the minimum width defined in 4.4 are available between the inside edge of the vertical bearer bars and the leading edge of the first or trailing edge of the last symbol bars respectively. The width of the bearer bar shall be between two and five times the *X* dimension of the symbol.

A.2 Check characters

A.2.1 Symbol check character

For applications requiring enhanced data security, a symbol check character should be used, in which case the symbol check character shall be encoded as the second character of the final digit pair, immediately following the final data character and before the stop pattern. The inclusion of the symbol check character shall be determined by the application standard.

NOTE Since the number of characters to be encoded, including the check character, is required to be even, a leading zero may need to be prefixed to the data string..

When included, the following symbol check character algorithm shall be used:

1) Starting with the digit on the right of the number (excluding the check character), sum all the alternate digit values, reading from right to left;

2) Multiply the result of step 1) by 3;

3) Sum all the remaining digit values;

4) Add the result of step 2) to the result of step 3);

5) The check character is the smallest number, which, when added to the result of step 4), produces a multiple of 10.

EXAMPLE: To calculate the check digit for the data 1937:

	1	**9**	**3**	**7**		
Step 1:		9	+	7	=	16
Step 2:			×	3	=	48
Step 3:	1	+	3		=	4
Step 4:		4	+	48	=	52
Step 5:	(next multiple of 10 is 60):	60	-	52	=	8

therefore C = 8

The full number is thus 19378, to which a leading zero now requires to be added to make an even number of digits for encodation purposes, i.e. the data encoded will be 019378.

The weighted modulo 10 complement symbol check character should be transmitted by the decoder.

A.2.2 Data check character

An algorithm as described in ISO 7064, or another algorithm defined in the application specification, may be used to calculate a data check character, provided that suitable provision for its calculation and verification is included in the symbol generation and message processing software. Such a data check character should be the final character of the data string and shall be transmitted by the decoder.

A.3 Human-readable interpretation

A human-readable interpretation of the data characters (and symbol check character, if used) should normally be printed with the "Interleaved 2 of 5" symbol encoding them. Start/stop patterns have no human-readable interpretation. Character size and font are not specified, and the interpretation may be printed anywhere in the area surrounding the symbol, as long as quiet zones are not encroached upon.

Annex B
(informative)

Guidelines for the use of Interleaved 2 of 5

B.1 Autodiscrimination compatibility

Interleaved 2 of 5 symbols may be read by suitably programmed bar code readers that are designed to autodiscriminate them from other symbologies. The code is, in particular, fully distinguishable from and thus compatible with many symbologies including the symbologies standardised by ISO/IEC.

The decoder's valid set of symbologies should be limited to those needed by a given application to maximize reading security.

When Interleaved 2 of 5 is used in an autodiscrimination environment with Code 39 symbols, the following guidelines shall be followed:

a) The nominal intercharacter gaps in the Code 39 symbols shall be no wider than the narrow elements;

b) The reading system shall be constrained and the decoder programmed to ensure that the number of characters (including start and stop characters) in all Code 39 symbols is greater than one-half of the number of data characters in the Interleaved 2 of 5 symbols;

c) Interleaved 2 of 5 symbols shall have a minimum length of six characters in environments where they are autodiscriminated with Code 39.

The use of the recommendations in A.1 and A.2 will provide additional protection in an autodiscrimination environment.

B.2 System considerations

It is important that the various components (printers, labels, scanners) making up a bar code installation operate together as a system. A failure in any component, or a mismatch between them, can compromise the performance of the overall system. The characteristics of the printer, symbol and scanner should be matched to achieve the desired performance.

B.3 Printing considerations

This section describes considerations for printing Interleaved 2 of 5 using pixel-based printers, however, these same considerations are applicable to all symbologies.

B.3.1 Pixel-based printing

Graphics software used to create bar codes on pixel-based printers must scale each bar and space exactly to the pixel pitch of the printer being used, irrespective of the symbology. For two-width symbologies like Interleaved 2 of 5 the number of pixels comprising narrow bar and space elements, before any compensation for bar width growth or loss, shall be a fixed and constant integer, and the number of pixels comprising wide elements, before any compensation for bar width growth or loss, shall be the integer product of the number of pixels in the narrow element multiplied by the wide : narrow ratio. The width of any required inter-character gap shall also be a fixed integer number of pixels. Therefore, a given printer can only print a certain set of *X* dimensions and wide : narrow ratios.

Compensation for uniform bar width growth (or loss) must be in equal offsetting amounts on all bars and spaces in the symbol. This may be accomplished by changing an integer number of pixels from dark to light or light to dark in the same manner for each bar-space pair in the symbol and for the last bar in the symbol. For example, all pixels along the same edge of every bar in the symbol could be changed from dark to light, or pixels along both edges of every bar in the symbol could be changed from dark to light, provided that the printer resolution is sufficient to allow this to be performed satisfactorily. Any set of dark to light or light to dark pixel changes is acceptable provided the adjustment is performed consistently across the whole symbol and does not change the total symbol character width. Failure to follow these principles results in degraded symbol quality and often results in unreadable symbols.

General purpose printing software designed to support a wide range of printers should provide the user with the capability of adjusting the *X* dimension and bar width growth or loss.

Programmer's Example

These principles can be reduced to the following rules for digital bar code design files:

1) Convert the desired magnification or *X* dimension to a narrow element width in pixels rounded down to the nearest integer and select a wide : narrow ratio that will result in an integer number of pixels in the wide elements.

2) Determine the number of pixels corresponding to the desired compensation for uniform bar width growth and round up to the next larger integer.

3) Apply the above results to determine the pixel count of every bar and space in the symbol.

EXAMPLE:

Using digital bar code design files with a printing device with 24 dots per mm, create a 0,27 mm *X* dimension symbol with 2,5 : 1 wide : narrow ratio and with 0,06 mm of bar width reduction.

— The narrow element size is 24 dots/mm × 0,27 mm = 6,5 pixels, which is rounded down to 6 pixels per narrow element.

— The wide element size is therefore 6 × 2,5 = 15 pixels

— The bar growth compensation is 0,06 mm × 24 pixels/mm = 1,4 pixels, which is rounded up to 2 pixels.

This process results in the following pixel count for bars and spaces as illustrated in Table B.1.

Table B.1 — Correcting Pixels for Imaging Resolution and Bar Width Reduction

	Pixel Count	
	Bars	Spaces
Narrow elements	4	8
Wide elements	13	17

B.3.2 Guidance to users of pixel-based printing software

When printing a symbol for the first time on a printing system consisting of the bar code printing software and the printing device, a user should verify according to ISO/IEC 15416 that the printed symbol meets the required print quality grade and *X* dimension. If the resulting symbol does not achieve the required symbol quality grade the user may need to increase the *X* dimension or change the bar width growth or loss. If the *X* dimension is increased the user should verify that the minimum quiet zones are maintained. This process may need to be repeated until the required symbol grade is achieved. Not all printing systems are capable of producing acceptable symbols at small *X* dimensions.

B.3.3 Process control considerations

For process control purposes, the assessment of average bar width gain or loss, and the application of corrective action to reduce this, are appropriate. The "decodability" parameter measured in accordance with ISO/IEC 15416 is affected by systematic bar width gain or loss.